INDOOR AIR QUALITY ASSESSMENT

North Reading High School
189 Park Street
North Reading, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of Wayne Hardacker, Supervisor of Buildings and Grounds for the North Reading School Department, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) was asked to provide assistance and consultation regarding indoor air quality issues at North Reading High School in North Reading, Massachusetts.

On February 16, 2001, a visit was made to this school by Cory Holmes, Environmental Analyst, Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, and Suzan Donahue, Research Assistant for BEHA's ER/IAQ program, to conduct an indoor air quality assessment. BEHA staff were accompanied for parts of the inspection by Mr. Hardacker and Rich Vittozzi, Head Custodian.

The school is a one-story cinderblock/brick building originally built in 1957. There are three distinct areas: A-wing, B-wing, and C-wing. The building was completely renovated in 1989, including the addition of a library between B-C wings. The school is located on a grade in a step-like fashion, with A-wing located downhill from the C-wing. A-wing originally contained the shop areas (wood, automotive), that were discontinued prior to this assessment. Art rooms, gym, auditorium, music room, and administration/guidance offices are located in the A-wing. The basement/crawlspace under A-wing is also used by building occupants. Theater sets/props storage beneath the auditorium-stage area of the crawlspace, a maintenance office, and a baseball batting practice area are located in the basement/crawlspace. The B-wing contains general classrooms, a cafeteria, and a darkroom. The C-wing contains general classrooms, computer labs, science classrooms and chemical storage areas.

Methods

Air tests for carbon dioxide were taken with the Telaire, Carbon Dioxide Monitor and a TSI, Q-Trak IAQ Monitor Model 8551. Tests for temperature and relative humidity were taken with a Mannix, TH Pen PTH 8708 Thermo-Hygrometer as well as a TSI, Q-Trak IAQ Monitor Model 8551. Air tests for carbon monoxide were taken with the TSI, Q-Trak IAQ Monitor Model 8551.

Results

The school houses grades nine through twelve and has a student population of approximately 550 and a staff of approximately 75. Tests were taken during normal operations. Test results appear in Tables 1-11.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in fifty-four of the seventy-six areas surveyed, indicating an overall ventilation problem in the school. C-wing had carbon dioxide levels in excess of 2,000 ppm in seven classrooms, indicating little or no air exchange in these areas.

Ventilation in classrooms and in the cafeteria is provided by a unit ventilator (univent) system (see Picture 1). Univents are designed to draw air from outdoors through a fresh air intake located on exterior walls of the building and return air through an intake located at the base of each unit (see Figure 1). Fresh air and return air are

mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. Univents were deactivated in many classrooms. Obstructions on and around univents, such as books, papers and posters on air diffusers, as well as bookcases, tables and desks in front of return vents, were also seen in a number of classrooms. To function as designed, univent air diffusers and returns must remain free of obstructions. Importantly, these units must be activated and allowed to operate during hours of school occupation. Ventilation to common areas (e.g., auditorium, gymnasium & library) is provided by rooftop air handling units (AHUs).

The mechanical exhaust ventilation system for classrooms consists of ducted, grated wall vents (see Picture 2); many of which were obstructed by furniture, storage carts, shelves and other items (see Picture 3). Exhaust vents were not drawing air in a number of classrooms, which can indicate that the exhaust ventilation was turned off, or that rooftop motors were not functioning. BEHA staff and Mr. Hardacker examined exhaust motors on the roof. It was determined that a number of these motors were not functioning or did not have fan belts (see Table 10 "Roof Notes"). Complaints of odors/backdrafts from the exhaust vents were expressed to BEHA staff in several areas: specifically in classroom A104, the boys' locker room and in a number of restrooms. While no odors were detected on the day of this assessment, backdrafting of air from exhaust vents was noted.

No exhaust ventilation within the cafeteria could be identified. It appeared that exhaust ventilation was provided for the cafeteria by a large exhaust hood centrally located in the kitchen (see Picture 4). When activated the exhaust hood creates negative pressure in the kitchen which draws air from the cafeteria through a series of passive vents (see Picture 5) into the kitchen and out the exhaust hood. On the day of the

assessment the kitchen hood was deactivated, therefore no exhaust ventilation was being provided for either the kitchen or cafeteria.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings ranged from 65 ^{o} F to 77 ^{o} F, which were within the BEHA recommended range for comfort in most areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. A number of temperature complaints were expressed to BEHA staff during the assessment (see Tables), which may indicate problems with the pneumatic control system or that thermostats are in need of calibration. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity in the building ranged from 8 to 45 percent, which was below the BEHA recommended comfort range in some areas. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Several areas had water stained ceiling tiles (see Tables). Water-damaged ceiling tiles can provide a source of microbial growth and should be replaced after a water leak is

discovered. Vines were growing on the exterior walls of the building, within the courtyard (see Picture 6). The tendrils of vines can work their way into mortar and brickwork causing cracks and fissures. Rainwater can also accumulate between vines and brickwork, which can lead to water penetration undermining the integrity of the building envelope.

There is a basement/crawlspace beneath the school which has a dirt floor. The crawlspace can be entered through the receiving room (A111), the stage area of the auditorium, or hatchways in various locations (see Picture 7). The soil and other materials within the crawlspace can support mold growth when exposed to moisture. Materials that can support mold growth, include carpets (which were reportedly placed in the crawlspace to keep dust down), its dirt floor, pipe insulation, and stored items. Active leaks were also noted in the crawlspace from holes/expansion joints in the foundation, with pooling water located, along the northern wall of A-wing crawlspace. Pooling water can become stagnant and become a source for bacterial/algal growth/odors. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that water damaged materials be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If moistened materials are not dried within this time frame, mold growth may occur.

Crawlspaces are considered unconditioned space. Air in this type of unconditioned space tends to be colder than occupied areas. As heat is generated by radiators or univents, airflow through cracks or spaces in the floor or wall cavities can be generated as the colder air moves into the area vacated by rising heated air. As this airflow is created, odors and particulate matter from the crawlspace can move with airflow into occupied spaces. Any cracks or seams in floor boards, exterior wall cavities,

or holes in the floor for utilities can serve as pathways for air, mold spores and associated materials to move from the crawlspace into occupied areas. Certain individuals can be sensitive to mold growth, which can result in irritation of the eyes, nose, throat or the respiratory system.

Plants were noted in several classrooms and can be a source of pollen and mold. Pollen and mold can be respiratory irritants to some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold. A large hanging plant was located over carpet in the main office (see Picture 8). If over-watering occurs, the carpet can get wetted, which can result in potential for mold growth (see above).

Other Concerns

Several other conditions were noted during the assessment, which can affect indoor air quality. Of note is the condition of the flameproof cabinets in each of the three chemical storerooms within science classrooms in C-wing. Each of these cabinets is ducted with PVC pipe to a rooftop exhaust vent (see Picture 9). No draw of air was detected by BEHA staff at the time of the inspection. The National Fire Prevention Association (NFPA) does not require venting in flammable storage cabinets, however, if venting is done, it must be vented directly outdoors and in a manner not to compromise the specific performance of the cabinet (NFPA, 1996). If air back-flow from outdoors into the cabinet through the venting occurs, off-gassing chemicals can be forced from the flammable storage cabinet into the storeroom. The installation of a damper or mechanical exhaust fan should prevent air back-flow into the cabinet.

Other conditions of note in the chemical storage areas include:

- Acidic and alkaline materials were noted stored on the same shelf in the flammables cabinet. Reactive materials should be stored separately.
- An old bottle of carbon tetrachloride was observed in one of the flammable cabinets. Carbon tetrachloride is not flammable and is considered to be an extremely hazardous substance that can evaporate at room temperature (NPFA, 1991). The condition of the container may lead to evporation of carbon tetrachloride from the container.
- Other chemicals observed appeared to be of extreme age.

It is recommended that periodic inventory of chemicals in the science department be done on an ongoing basis to assess chemical storage and dispose of unwanted chemicals. Disposal of unwanted chemicals in a manner consistent with Massachusetts hazardous waste laws is recommended.

The dark room uses a number of developing chemicals that create odors in this room. Photographic chemicals contain volatile organic compounds (VOCs), which can be irritating to the eyes, nose and throat. Local exhaust ventilation exists in this room, which is activated by a switch. Local exhaust vents should be located at the level of the wash sink and developing pans to draw odors away from users. The location of the exhaust fan in the ceiling will tend to draw odors into users of the wash sink and developing pans (see Figure 2). There also appears to be an exhaust vent connected to the school's general exhaust system in this room. Under certain conditions, VOCs can be a fire hazard and need to be exhausted from the building by a system that is separate from the main exhaust ventilation system of the school. Darkroom vapors can be entrained by the exhaust vent and introduce these pollutants to other sections of the school connected to ductwork of this vent.

The interior of the univent in classroom B104 was opened. Univents at this school are equipped with metal racks, which filter materials are cut to fit that strain particulates from airflow. The material used for filter media in these metal racks provides minimal filtration of respirable particulates that can be distributed by univents. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent (Minimum Efficiency Reporting Value equal to 9) would be sufficient to reduce many airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increasing filtration can reduce airflow (called pressure drop) which can reduce the efficiency of the univents due to increased resistance. Prior to any increase of filtration, each univent should be evaluated by a ventilation engineer to ascertain whether it can maintain function with more efficient filters.

Complaints related to vehicle exhaust infiltration were expressed to BEHA staff. Located adjacent to the south side of C-wing is the bus parking lot for the North Reading school system (see Picture 10). BEHA staff received several complaints concerning vehicle exhaust odors in C-wing. Idling buses in the parking lot near the school can result in vehicle exhaust entrainment by the mechanical ventilation system and open windows under certain weather conditions; which may, in turn, provide opportunities for exposure to combustion products such as carbon monoxide. At the time of the assessment no vehicle exhaust odors or measurable levels of carbon monoxide were detected within the school. M.G.L. chapter 90 section 16A prohibits the unnecessary

operation of the engine of a motor vehicle for a foreseeable time in excess of five minutes (MGL. 1996).

The restroom in the principal's office did not have exhaust ventilation. Several other restroom exhaust vents were not drawing air or, as mentioned, were backdrafting air. Exhaust ventilation is necessary in restrooms to remove moisture and to prevent restroom odors from penetrating into adjacent areas.

A number of cigarette butts/ashes were observed in the student restrooms (see Picture 11). Environmental tobacco smoke can have a marked effect on indoor air quality. The most effective method of preventing exposure to environmental tobacco smoke is to have smoke-free buildings. M.G.L. Chapter 270, Sec. 22 prohibits smoking in public buildings, except in an area which has been specifically designed as a smoking area (M.G.L., 1987).

The art room contains two unvented pottery kilns (see Picture 12). Kiln exhaust may contain corrosive, hazardous and irritating materials including chlorine, sulfur dioxide and carbon monoxide, and should be provided with dedicated local exhaust ventilation (McCann, 1985). Without local exhaust ventilation, pollutants produced by the pottery kiln can penetrate into adjacent occupied rooms in the school.

Rooms A105 and A108 contained abandoned fountain-type sinks. Locker rooms contain showers with floor drains. Abandoned or underused drains, if not properly wetted or sealed, can dry out and lead to sewer gas back up into classrooms. Sewer gas can be irritating to the eyes, nose and throat.

Photocopiers were noted in a number of locations throughout the school. The copy room contained two lamination machines. Lamination machines can produce irritating odors during use. VOCs and ozone can be produced by photocopiers,

particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, D., 1992). Photocopiers and lamination machines also create heat. No exhaust ventilation was provided for the photocopiers/lamination machines. Exhaust ventilation should be provided to remove pollutants, odors and excess heat from these work areas.

Also of note were the amount of materials stored inside classrooms. In several areas, items were observed piled on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items, (e.g., papers, folders, boxes, etc.) also make it difficult for custodial staff to clean. Dust can be irritating to the eyes, nose and respiratory tract.

Accumulated chalk dust was observed in several classrooms (see Picture 13). Chalk dust is a fine particulate, which can become easily aerosolized and serve as an eye and respiratory irritant. Utility holes around pipes and missing ceiling tiles were also observed in several areas of the school. Open utility holes can provide a means of egress for odors, fumes, dusts and vapors between rooms and floors. The movement of ceiling tiles can introduce dirt, dust and particulate matter into occupied areas of the school.

Several classrooms contained dry erase boards and dry erase markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, (e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999). Cleaning products were found in a number of classrooms. Cleaning products, all well as dry erase board markers and cleaners, may contain chemicals that can be irritating to the eyes, nose and throat.

The art room contains a spray booth that is vented to the outside. Located in close proximity to the spray booth exhaust vent is the art room's univent air intake (see

Picture 14). In its current configuration it is possible for materials used in the spray booth to be entrained into the univent air intake under certain wind and weather conditions.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy independent of classroom thermostat control.
2. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider contacting an HVAC engineer concerning the repair and calibration of thermostats and pneumatic controls for AHUs and univent fresh air control dampers school-wide.
3. Once HVAC repairs/calibrations are complete, the systems should be balanced by a ventilation engineer.
4. Inspect exhaust motors and belts for proper function, repair and replace as necessary.
5. Ensure kitchen vent hood is activated to provide exhaust ventilation to the kitchen/cafeteria. Examine the feasibility of provide independent exhaust ventilation to the cafeteria.
6. Remove all blockages from univents and exhaust vents.
7. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be

adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

8. Change filters in HVAC equipment as per the manufacturer's instructions to prevent the re-aerosolization of dirt, dust and particulate matter. Examine univents to ascertain whether filters with an increased dust spot efficiency that fit univent filter racks flush can be installed. Consider the use of disposable filters.
9. Keep plants away from univents in classrooms. Ensure plants have drip pans and examine drip pans for mold growth. Disinfect areas with an appropriate antimicrobial where necessary.
10. Examine the feasibility of improving drainage or using sump pumps in subterranean ventilation pits to prevent water pooling and microbial growth.
11. Repair roof leaks and replace any water-stained ceiling tiles. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
12. Clean chalkboards and trays regularly to prevent the build-up of excessive chalk dust.
13. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
14. Store chemicals and cleaning products properly and out of the reach of students.

15. Prohibit smoking in this building in accordance with Massachusetts law (M.G.L. Chapter 270, Sec. 22).

16. Inspect flammable cabinet venting system to ensure it is equipped with a damper or mechanical exhaust motor to prevent backdrafting into cabinet. If neither mechanism is present, remove vent pipe altogether and seal hole to make airtight.

17. Have a chemical inventory done in all storage areas and classrooms. Discard hazardous materials or empty containers of hazardous materials in a manner consistent with environmental statutes and regulations. Label chemical containers with the chemical name of its contents. Follow proper procedures for storing and securing hazardous materials.

18. Consider reconfiguring the photo developing sink and local exhaust ventilation in the darkroom to draw chemical vapors away from occupants. Consider consulting a ventilation engineer to assess whether the existing exhaust mechanical ventilation system can be adapted.

19. Provide adequate local exhaust ventilation for lamination machines, photocopiers and mimeographs when used.

20. Wet traps of drains at least once a week or properly seal abandoned drains to prevent the back up of sewer gas.

21. Relocate bus parking area or have busses shut off engines after five minutes as required by Massachusetts General Laws 90:16A.

22. Remove carpets from crawlspace and replace with a non-porous, water-resistant material (e.g., rubber or plastic).

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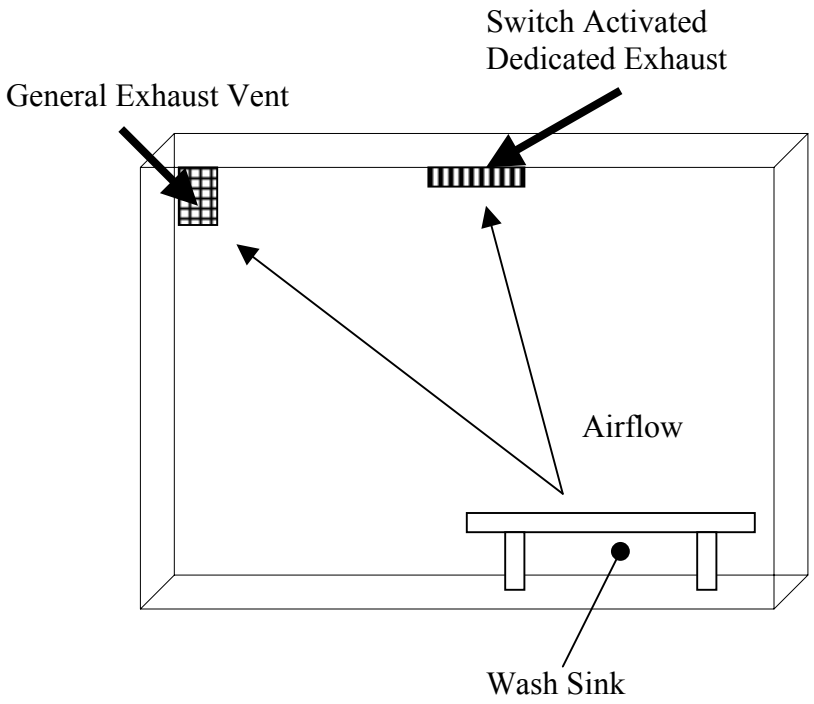
Figure 2 **Dark Room Local/General Exhaust Vent Configuration**



(Drawing is an example, not an actual representation)

Picture 1

Classroom Univent: Note Items on Top

Picture 2

Classroom Exhaust Vent

Picture 3

Exhaust Vent Blocked by Items

Picture 4

Kitchen Exhaust Hood

Picture 5

Passive Vent in Cafeteria

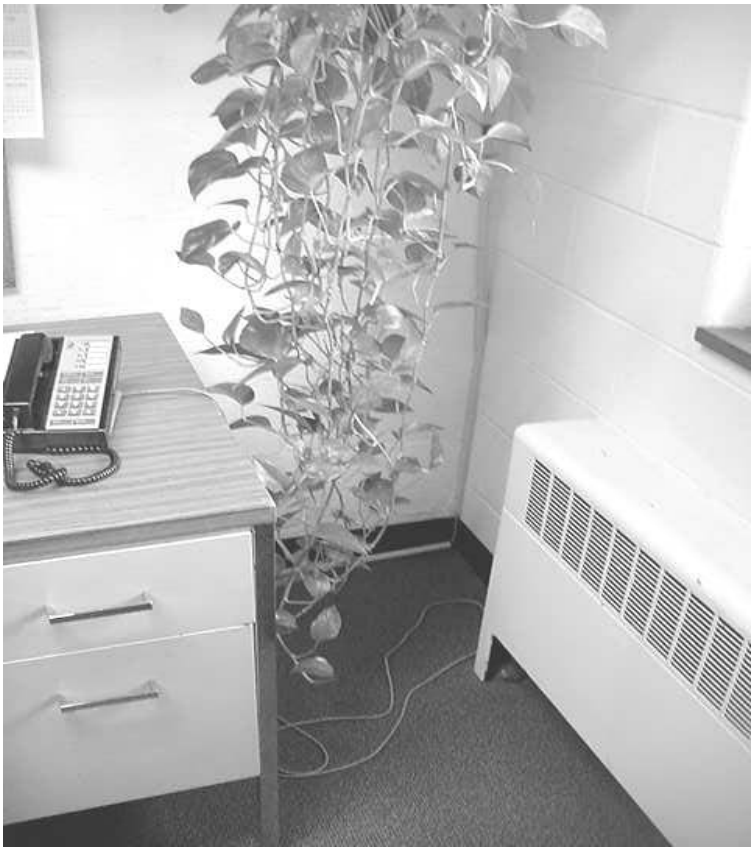
Picture 6

Clinging Vines in School Courtyard

Picture 7

Hatchway Entrance to Crawlspace

Picture 8



Hanging Plant over Carpet

Picture 9

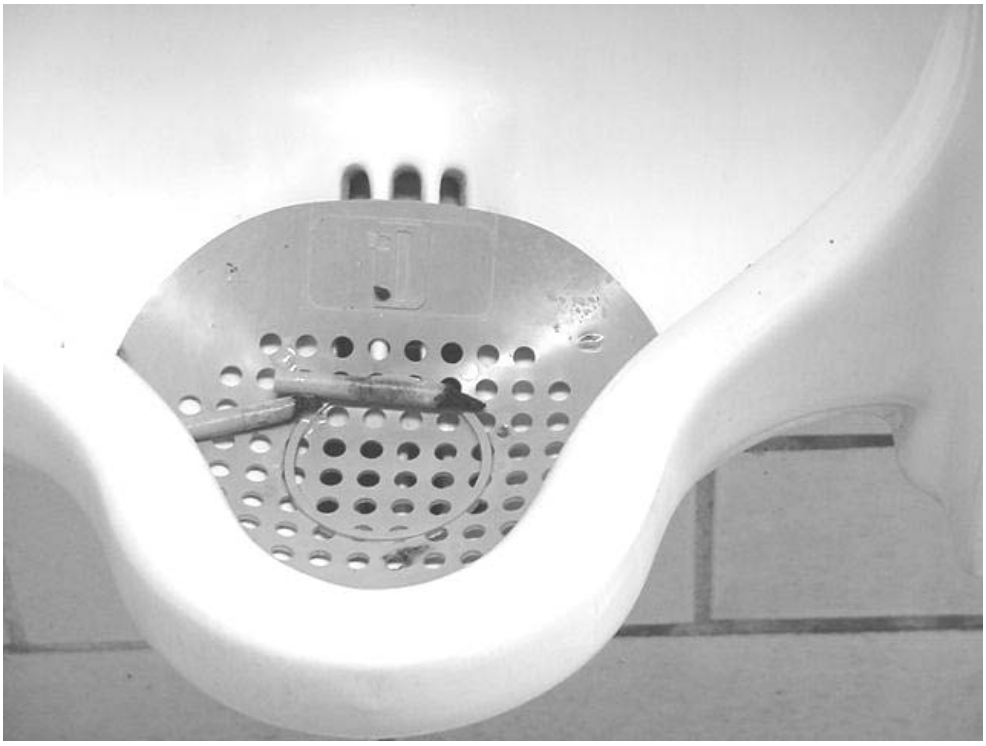
Flammables Cabinet Ducted to Roof by PVC Pipe

Picture 10

Univent Air Intake

School Bus Parking: Note Close Vicinity to Univent Air Intake

Picture 11



Cigarette Butts in Urinal

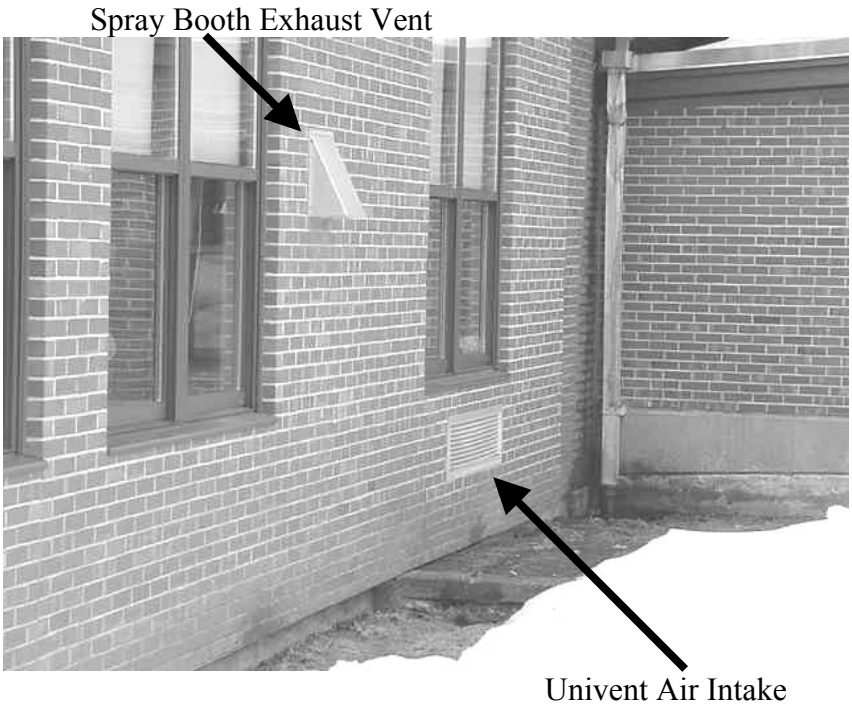
Picture 12

Unvented Kilns in Art Room

Picture 13

Accumulated Chalk Dust in Classroom

Picture 14



Proximity of Spray Booth Exhaust Vent to Univent Air Intake, Note Spray Booth Vent Forces Exhausted Materials Down

TABLE 1

Indoor Air Test Results – North Reading High School, North Reading, MA – February 16, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	496	31	39					weather conditions: overcast
Principal's Office	1126	70	15	3	Yes	Yes	No	univent off, carpet, private restroom-no exhaust
Main Office	955	71	17	2	Yes	Yes	No	univent off-return blocked, 3 plants-1 hanging plant over univent, photocopier
Guidance Office	1124	71	19	2	No	No	No	
Guidance L-Z	1150	71	21	1	Yes	No	No	carpet
Guidance A-K	1074	72	19	0	Yes	No	No	
Control Room-clock systems		72	23	0	No	No	Yes	
Nurse's Office	1103	72	18	2	No	Yes	No	supply located in hallway/corridor outside restroom, restroom exhaust vent on
Sick Room	1108	74	20	0	Yes	No	No	

*** ppm = parts per million parts of air**
CT = ceiling tiles
CO = carbon monoxide

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – North Reading High School, North Reading, MA – February 16, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Occupational Ed	720	73	13	1	Yes	No	No	window open, carpet, reports of septic odors
Women's Restroom						Yes	Yes	ventilation weak/off, floor drain
Library	907	72	11	~25	Yes	Yes (6)	Yes (2)	~10 computers, carpet, reports of uneven heating/cooling, temperature complaints-cold, thermostat override
Library Work Room	749	70	11	0	No	Yes (2)	Yes	dry erase board cleaner, cleaners/gum remover under sink, 2 water damaged CT
AV Office	622	71	11	1	No	No	No	personal fan, main frame
B-Wing, Women's Faculty	656	68	19	0	Yes	Yes	No	supply off, plant/dried arrangement
B-Wing, Women's Faculty Restroom						No	Yes	exhaust vent occluded-no draw, wall mounted spray air freshener
B-Wing, Girl's Restroom						No	Yes	exhaust vent occluded-drawing air, cigarette ashes
Social Studies Office	845	70	17	0	Yes	No	Yes	plant, accumulated items

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Comfort Guidelines

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Temperature -	70 - 78 °F
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TABLE 3

Indoor Air Test Results – North Reading High School, North Reading, MA – February 16, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
C105	1460	75	20	18	Yes	Yes	Yes	univent off, chalk dust
C104	1398	74	19	17	Yes	Yes	Yes	accumulated debris inside univent-fan off/heat only, exhaust blocked by table, chalk dust
C103	1272	75	18	15	Yes	Yes	Yes	univent fan off/heat only, chalk dust
C102	1179	74	18	24	Yes	Yes	Yes	supply vent on-occluded, door open, chalk dust
C101	996	74	19	0	Yes	Yes	Yes	univent return blocked by desk-fan off/heat only, chalk dust
C134	1458	77	23	20	Yes	Yes	Yes	dry erase board
Science Office	925	73	13	0	No	Yes	Yes	exhaust weak, main frame equipment, books
C110	1503	73	20	20	Yes	Yes	Yes	items on univent, exhaust weak, dry erase board/cleaner, plant
C111	1194	72	18	0	Yes	Yes	Yes	exhaust off, 2 missing CT, 2 water damaged CT, 7 sinks, incubator
C113	2000+	68	36	0	Yes	Yes	Yes	exhaust weak/off, univent fan off/heat only, 2 sinks, chem.

*** ppm = parts per million parts of air**
CT = ceiling tiles
CO = carbon monoxide

Comfort Guidelines

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	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 4

Indoor Air Test Results – North Reading High School, North Reading, MA – February 16, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
								storage room
C115	1404	67	31	18	Yes	Yes	Yes	3 sinks, chalk dust, flammables room
C118	1293	69	21	0	Yes	Yes (2)	Yes	exhaust vent on timer/switch, 8 sinks, missing CT, chem. storage
Auditorium	778	68	22	14	No	Yes	Yes	Access to crawlspace
Math Office	951	71	29	0	Yes	No	Yes	
C131	1325	72	30	20	Yes	Yes	Yes	CO=0
C132	2240	75	36	24	Yes	Yes	Yes	Univent fan off/heat only
C133	1810	76	31	18	Yes	Yes	Yes	Univent fan off/heat only, chalk dust
Foreign Language Office	1216	70	30	0	Yes	No	No	Access hatch to crawlspace-hole in hatch
C126	3540	71	42	20	Yes	Yes	Yes	Univent and exhaust off, dry erase board

*** ppm = parts per million parts of air**
CT = ceiling tiles
CO = carbon monoxide

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 5

Indoor Air Test Results – North Reading High School, North Reading, MA – February 16, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
C125	2656	71	40	0	Yes	Yes	Yes	Univent and exhaust off, 1 plant, 2 missing CT, plug in air freshener
C124	2105	71	38	1	Yes	Yes	Yes	Univent and exhaust off, chalk dust
C123	3808	73	45	21	Yes	Yes	Yes	Univent and exhaust off
C122	2010	71	32	19	Yes	Yes	Yes	Exhaust off, door open, chalk dust, CO=0
C121	1621	70	32	2	Yes	Yes	Yes	Univent and exhaust off, 25+ computers
Business Education Office	1572	72	32	2	Yes	No	Yes	Exhaust off, mold complaints
C120	1840	73	29	22	Yes	Yes	Yes	Exhaust off-obstructed by file cabinet, 25+ computers,
Faculty Dining Room	760	69	34	4	Yes	Yes	Yes	Exhaust blocked by soda machine/water cooler, 1 water damaged CT
Cafeteria	1430	69	36	~150	Yes	Yes	Yes	2 univents, cafeteria uses kitchen hood for exhaust, passive door vents sealed, CO=0

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Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 6

Indoor Air Test Results – North Reading High School, North Reading, MA – February 16, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Kitchen Restroom					Yes	No	No	
Kitchen	1490	70	35	5	Yes	Yes	Yes	Exhaust hood off
B109	1262	72	29	12	Yes	Yes	No	Room divided in 2, chalk dust
B107, Cable Station	919	72	31	1	No	Yes	Yes	Ventilation systems off, temperature issues
B140	700	72	23	0	Yes	Yes	Yes	CO=0
B141	901	72	23	1	Yes	Yes	Yes	Univent noise, exhaust off, 1 plant-flowering plant on univent
B142	1500	73	28	11	Yes	Yes	Yes	Univent fan off/heat only, chalk dust
B143	1447	73	25	14	Yes	Yes	Yes	Exhaust weak, chalk dust, CO=0
B103	999	72	28	0	Yes	Yes	Yes	Exhaust vent partially obstructed, 6 plants
A101	1776	73	31	25	Yes	Yes	Yes	Exhaust vent partially obstructed/off, spray booth vented to outside near univent intake,

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Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 7

Indoor Air Test Results – North Reading High School, North Reading, MA – February 16, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
								CO=0
A-Wing, Men's Restroom					No	No	Yes	Complaints of poor exhaust ventilation/odors
A104	1190	75	28	10	Yes	Yes	Yes	Exhaust off/backdrafting, univent deactivated by occupant-"cold air"
Music Room	798	72	16	14	Yes	Yes	Yes	Exhaust vent blocked by instruments, spaces around exterior door, 2 buckled CT
Music Office	758	72	22	0	Yes	No	No	Accumulated items, 1 water damaged CT, coffee odor
Upper Faculty Lounge	917	73	19	8	Yes	Yes	Yes	Coats on top of univent
B108	885	72	16	2	Yes	Yes	Yes	Box on univent, dry erase board/cleaner, sliding wall
English Office	896	73	16	0	Yes	No	No	Books
B104	1309	70	19	0	Yes	Yes	Yes	Univent off-opened to inspect filter-filter material cut to size
Darkroom				0	No	Yes	Yes	Passive wall vent to room B104, switch activated exhaust and

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Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 8

Indoor Air Test Results – North Reading High School, North Reading, MA – February 16, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
								common exhaust vent to school, door open
B102	1065	71	15	12	Yes	Yes	Yes	Books on univent-blocking ~2/3 of diffuser, chalk dust, door open
B101	1149	72	18	12	Yes	Yes	Yes	Door open
A144	899	72	13	20	Yes	Yes	Yes	Exhaust blocked by file cabinet/cart-off, spray cleaner on chalk tray, chalk dust
A143	1007	73	16	14	Yes	Yes	Yes	Univent fan off/heat only, exhaust backdrafting, accumulated items, chalk dust, door open
A105	740	73	22	0	No	Yes	Yes	2 un-vented kilns against garage door
A-Wing, Handicapped Restroom					No	No	Yes	Exhaust off, complaints of poor ventilation/odors/excess humidity
A108	746	72	24	2	Yes	Yes	Yes	Exhaust weak/off-grill missing
Boy's Locker Room	604	69	21	0	Yes	Yes	Yes	Univent off, exhaust off/backdrafting, exposed

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Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 9

Indoor Air Test Results – North Reading High School, North Reading, MA – February 16, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
								fiberglass on pipes
Boy's Shower Room							Yes	Exhaust off
Restroom							Yes	Exhaust off
Baseball Coach's Office	756	70	24	0	Yes	No	Yes	Exhaust off-located in restroom
A-Wing-Girl's Restroom							Yes	Cigarette ashes
Girl's Locker Room	616	71	14	0	Yes	Yes (2)	Yes	Supply and exhaust off, restroom exhaust off
Girl's Locker Room Office	612	69	15	0	Yes	No	No	restroom exhaust on
Gym	594	71	12	~45	No	Yes	Yes	Exhaust vents-no draw, some water damage to pipe insulation
Weight Room	588	73	12	0	Yes	Yes	Yes	
Athletic Director's Office	558	71	8	1	No	No	Yes	Exhaust off, door open, cleaners/food on shelves, utility holes

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Temperature -	70 - 78 °F
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TABLE 10

Indoor Air Test Results – North Reading High School, North Reading, MA – February 16, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Receiving Room	547	65	10	2	No	No	Yes	Exhaust off, mops/cleaners
Maintenance Shop	570	67	31	0	No	No	No	Screens to crawlspace, un-vented grinding machine/drill/sander
Crawlspace notes								Dirt floor, carpets, pooling water-NE wall
Guidance A	1130	69	36	0	Yes	No	No	Hanging plant over carpet, CO=0
Guidance B	1190	70	35	1	Yes	No	No	CO=0
Guidance Restroom (Men's)						No	Yes	Reported history of sewer gas odors, no passive door vent, exhaust off
Copy Room	765	70	27	2	No	No	Yes	Heat/humidity complaints, equipment malfunction, lamination machine (2), humidifier, no make-up air
Men's Faculty					No	No	Yes	Odor complaints
Boy's Handicapped Restroom					No	No	Yes	Exhaust off, temperature complaints-cold, no radiant heat

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Temperature -	70 - 78 °F
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TABLE 11

Indoor Air Test Results – North Reading High School, North Reading, MA – February 16, 2001

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
C-Wing, Boy's Restroom					No	No	Yes	Cigarette butts in urinals
C129, (Computer Room)	739	70	26	1	Yes	Yes	Yes	20+ computers, CO=0
Roof Notes								The following exhaust motors were found to be off: Shop wing-A5-Line A B wing AHU – off A5-line B 2 exhaust vents above library C wing #s 13,14,15,17,18,19

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Temperature -	70 - 78 °F
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